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ABSTRACT

This five-lesson unit is designed to give students a flavor of what the study of economics is about, to strengthen mathematical concepts the students already know, to allow them to experience the interrelationship between the two fields of mathematics and economics and to experience success and enjoyment. Topics of instruction include: (1) types of graphs used in economics and examples of their use; (2) relationships between tabular and graphic presentations; (3) the importance of slope in linear and non-linear situations; (4) tangent as slope; (5) supply and demand laws and the point of equilibrium; (6) the importance of labeling a graph; (7) the equation form of supply and demand; and (8) gross national product in current and constant dollars and the percent of change. The pattern suggested for covering topics includes reviewing a basic graph pattern, working through a problem from a typical mathematics book, demonstrating an application of the principle in the field of economics and an assignment from the field of economics. (PK)

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MATHEMATICS EDUCATION TRUST

ECONOGRAPHS FOR GRAPHACONS

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ECONOGRAPHS FOR GRAPHACONS*

One of the most difficult aspects of teaching high school mathematics it the successful integration of word problems into the various levels. The students find them difficult because of the reading, the necessity of translating word statements into usable mathematical statements, and the general lack of realism in the problems. "Pure mathematics" is always easier for the student and therefore easier for the teacher to teach, but our accomplishments in related fields would not be possible without strong backgrounds in "applied mathematics." One of the areas that demands skillful use of math is economics. Most economics textbooks are filled with graphs and formulas showing the history, projections, and implications of the various concepts. Frequently economics teachers do not have the time or background to thoroughly explain the mathematical concepts coupled with the fact that their students come from very diverse mathematical backgrounds.

Graphs are a part of our everyday life. They are commonly used in education, business, government and all types of news media to illustrate various concepts, many of them economic in nature. If graphs are so frequently used as a form of communication in the academic and non-academic world to depict these various types of relationships, the ability to read them, draw them and understand them is necessary. Even the most intimidating ones are quire easily mastered with a little effort. My intent in this unit is to give the students a flavor of what the study of economics is all about, to strengthen the math concepts they already know, to allow them to experience the interrelationship of the two fields, and to feel success and enjoyment while doing so. To fulfill this objective, I broke the work into several smaller areas. Basically these are the topics we discussed during the week and subsequently related each to the math they had previously studied:

*Title to be explained in evaluation.

1. The types of graphs used in economics (bar, line, curves, and circles) and examples of their use.
2. The relationship between a tabular and graphic presentation.
3. The importance of slope in linear and non-linear situations.
4. The tangent as slope.
5. The demand and supply laws (negative and positive slopes, respectively) and the point of equilibrium.
6. The importance of labeling a graph.
7. The equation form of supply and demand.
8. The gross national product in current and constant dollars and the percent of change.

We intiated our study by reviewing the types of graphs common in economics: the bar, line, curves and circles. We discussed why business graphs are generally first quadrant graphs in as much as positive production has positive results. The importance of labeling all lines was stressed both for accuracy and ease of communication.

The following is a suggested pattern for covering these topics; however, the length of time spent and the depth of each lesson will vary according to your own course objectives and class abilities. The introduction of each lesson was primarily a review of a basic graph pattern, after which I would

A. site and work through a problem from a typical math textbook;

B. demonstrate an application of the principle in the field of economics;

C. assign a problem(s) from the field of economics.

LESSON 1: BAR GRAPHS

A. Students are reminded that functions can be defined in different ways. They can use tables, correspondence, ordered pairs or a simple bar graph. A sample problem using menu offerings and the number of meals served in the school cafeteria would illustrate this.

CORRESPONDENCE:

Rib Ticklers.....575

Pizza.....700

Peanut Butter Sand....850

Chicken Salad.....600

Fish.....625

ORDERED PAIRS:

Rib Ticklers, 575

Pizza, 700

Peanut Butter Sand., 850

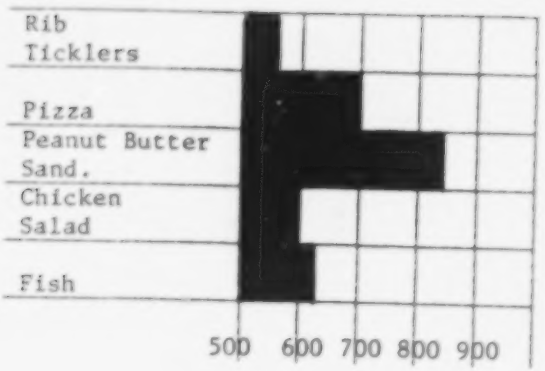
Chicken Salad, 600

Fish, 625

TABLE:

THIS WEEK'S MENU	
SELECTIONS	MEALS SERVED
RIB TICKLERS	575
PIZZA	700
PEANUT BUTTER SAND.	850
CHICKEN SALAD	600
FISH	625

BAR GRAPH:



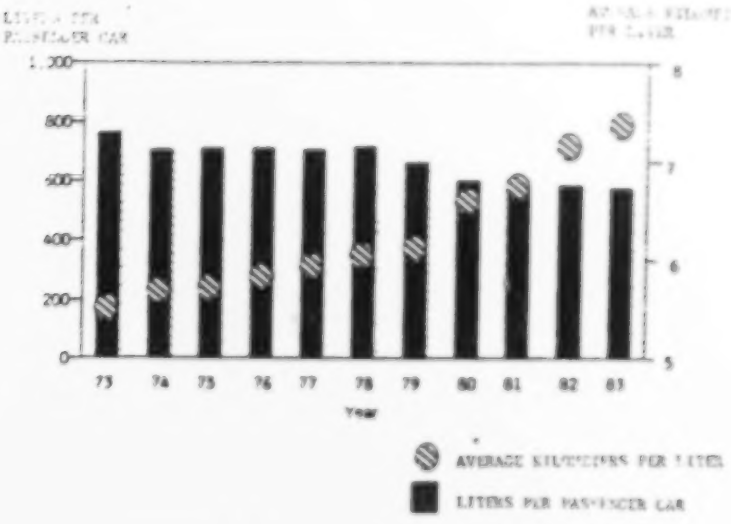
Students will agree that it is much easier to compare the facts in a bar graph.

B. This particular bar graph reflects two facts plotted against a specific year by preparing the left and right vertical scales to receive different information. Again, it is easier to read and use only the information you wish to study.

U.S. AVERAGE ANNUAL MILEAGE AND FUEL CONSUMPTION FOR PASSENGER CARS

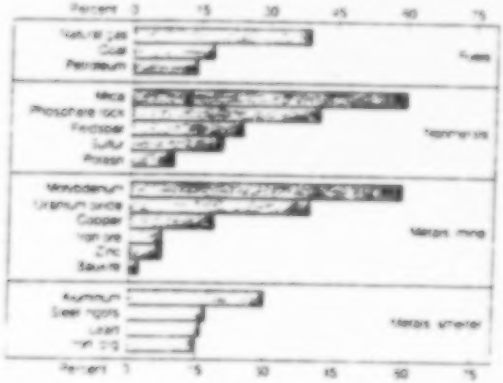
YEAR	MILEAGE IN KILOMETERS	FUEL CONSUMPTION IN LITERS	KILOMETERS PER LITER
1973	16 103	2 888	5.58
1974	15 298	2 665	5.74
1975	15 459	2 695	5.74
1976	15 781	2 691	5.86
1977	15 781	2 672	5.906
1978	16 264	2 706	6.01
1979	15 298	2 513	6.09
1980	14 654	2 282	6.42
1981	14 493	2 192	6.61
1982	15 298	2 222	6.88
1983	15 459	2 184	7.08

AVERAGE ANNUAL FUEL CONSUMPTION AND KILOMETERS PER LITER FOR PASSENGER CARS

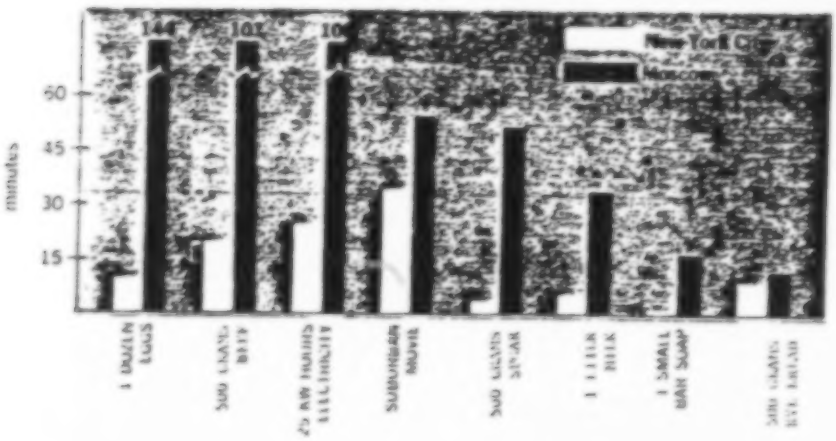


Some students may find double bars easier to read. A good example would be the U.S. Mineral Production as Percent of World Total: 1977, where the bars run horizontally and the units are subdivided by groups, or the Worktime Required to Buy Selected Commodities and Services in Moscow and New York City: 1976, which is vertical and color coded.

U.S. Mineral Production as Percent of World Total: 1977



Sources: Chart prepared by U.S. Bureau of the Census. Data from U.S. Bureau of Mines.



Source: National Industrial Conference Board

Worktime Required to Buy Selected Commodities and Services in Moscow and New York City, 1967

Graphs are very versatile. They can be as individual in character as the author but the material to be presented generally dictates the clearest mode of communication. The graphs will have authenticity only when the source of the information is cited.

C. Assignment: Given this table, draw a bar graph showing the U.S. Energy Consumption per Dollar of GNP.

U.S. Gross National Product, Population, and Consumption

Year	Gross National Product (billion 1972 dollars)	Population (millions)	Energy Consumption* Total	Per Dollar 1972 GNP	Per Person
1973	1,254.3	211.4	74.3	59.2	351
1974	1,246.3	213.3	72.5	58.2	340
1975	1,231.6	215.5	70.6	57.3	327
1976	1,298.2	217.6	74.4	57.3	342
1977	1,369.7	219.8	76.3	55.7	347
1978	1,438.6	221.1	78.1	54.3	352
1979	1,479.4	224.6	78.9	53.3	351
1980	1,475.0	227.2	76.0	51.5	334
1981	1,512.2	229.5	74.0	48.9	322
1982	1,480.0	231.8	70.8	47.9	306
1983	1,534.7	234.0	70.5	45.9	301
1984P	1,639.9	236.2	73.7	45.0	312

P = Preliminary data

*Total energy consumption is in quadrillion Btu, consumption per dollar of GNP is in thousand Btu, and per capita consumption is in million Btu.

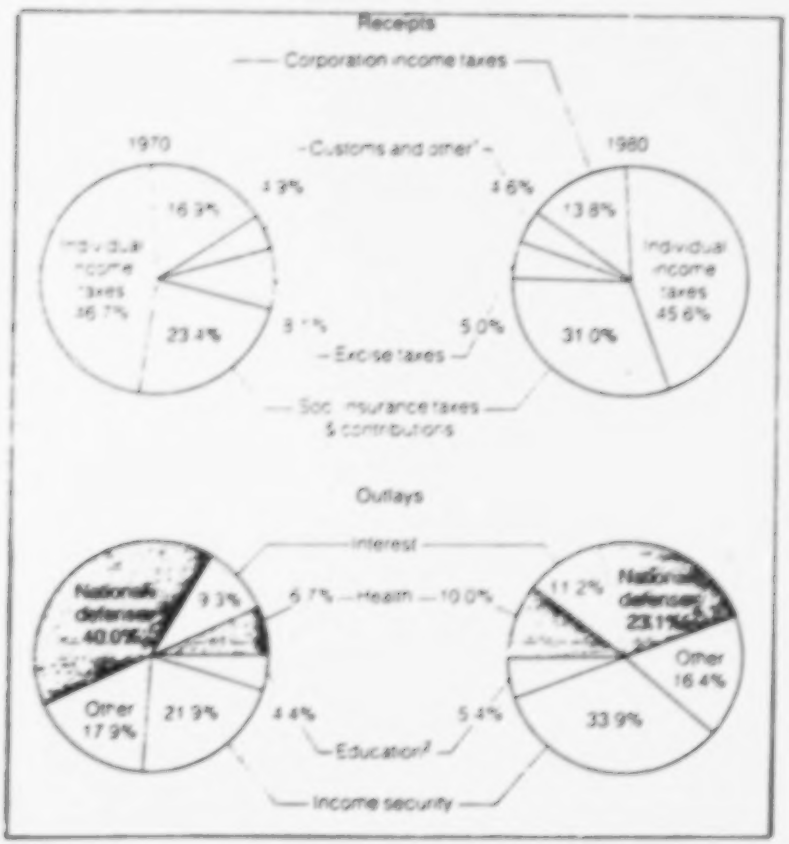
Source: U.S. Department of Commerce -- Bureau of Economic Analysis, Bureau of the Census; Energy Information Administration, *Annual Energy Review 1984*, and *Monthly Energy Review*, December 1984.

Examine the trends.

Look for reasons for the trends.

LESSON 2: CIRCLE GRAPHS

A. Circle graphs are more easily understood than most forms of graphing, particularly by the non-mathematical person. They do, however, require that the person making the graph convert the figures to a percent of the total and then take that percent of 360^{o} to allocate the correct portion of the circle. A circle graph gives a very visual comparison of statistics. I used the Federal Budget: Percent Distribution by Functions: 1970 and 1980. The tabular form was also presented so they could see the conversions and they then turned them into degrees and used protractors and compasses to construct the graphs.



Federal Budget – Percent Distribution by Function: 1970 and 1980

¹Other includes gift taxes and other receipts. ²Includes training, employment, and social services
Source: Chart prepared by U.S. Bureau of the Census

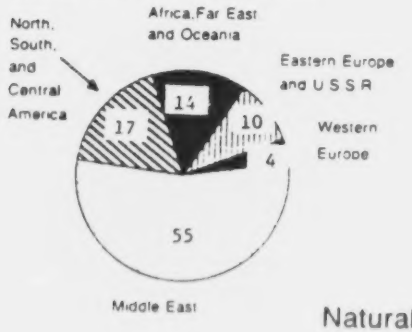
Not only was it an introduction to some economic principles but it served as an excellent review of basic skills that many of them had not practiced since they were in geometry classes.

B. Examine these circle graphs. What economic factors do you observe? What are the political implications of power seen in the graphs? (Now is the time to ask yourself how many languages you speak.)

World Fossil Fuel Reserves, January 1, 1984

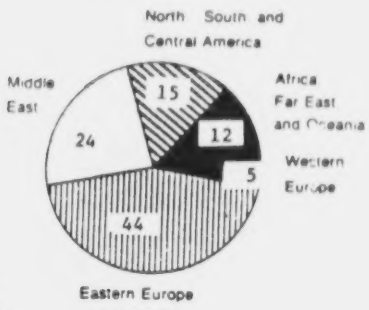
Crude Oil

BY PER CENT OF DISTRIBUTION



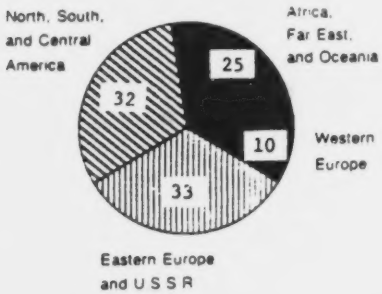
Natural Gas

BY PER CENT OF DISTRIBUTION



Coal

BY PER CENT OF DISTRIBUTION



Note. The Middle East has no known coal reserves

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Take time to demonstrate that 244.1/520 = 47% and that 47% of 360 degrees = 169 degrees. Which is easier to read...the table or the graph?

Ask the students, "Do you like what is happening according to the graphs?"

Federal Government Receipts, 1980 (In Billions of Dollars)

Source	Amount	Percent of Total
Individual income taxes	$244.1	47.0
Social insurance taxes and contributions	160.7	30.9
Corporate income taxes	64.6	12.4
Excise taxes	24.3	4.7
Customs duties	7.2	1.4
Estate and gift taxes	6.4	1.2
Miscellaneous	12.7	2.4
Total	$520.0	100.0

Source: "Table B–70. Federal Budget Receipts, Outlays, and Debt, Fiscal Years 1971–82," *Economic Report of the President* (Washington, D.C.: Government Printing Office, 1981), pp. 314–315.

Federal Government Outlays, 1980 (In Billions of Dollars)

Type of Expenditure	Amount	Percent of Total
Income security	$193.1	33.3
National defense	135.8	23.4
Net interest	64.5	11.1
Health	58.2	10.0
Education	30.8	5.3
Commerce and transportation	28.9	5.0
Veterans' benefits	21.2	3.7
Natural resources	20.1	3.5
International affairs	10.7	1.9
Community and regional development	10.1	1.7
Revenue sharing	8.6	1.5
General science, space, technology	5.7	1.0
Agriculture	4.8	0.8
General government	4.5	0.8
Law enforcement, justice	4.5	0.8
Undistributed offsetting receipts	−21.9	−3.8
Total	$579.6	100.0

Source: "Table B–70. Federal Budget Receipts, Outlays, and Debt, Fiscal Years 1971–82," *Economic Report of the President* (Washington, D.C.: Government Printing Office, 1981), pp. 314–315.

C. Assignment: Use this table to generate a bar graph for the totals in billion kilowatt hours and construct a circle graph reflecting the 1984 energy sources.

U.S. Net Electricity Generation by Energy Source
(Billion Kilowatthours)

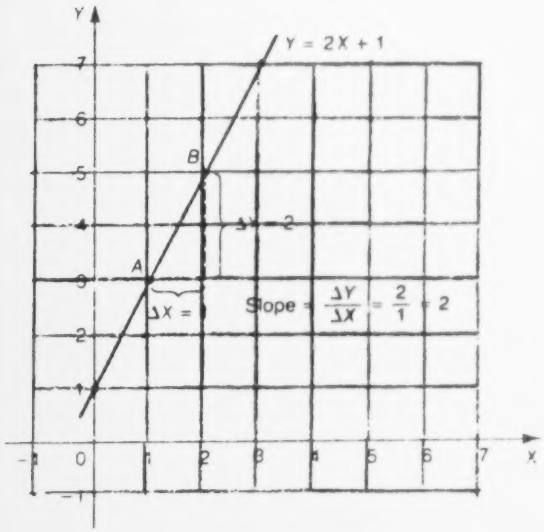
Year	Coal	Petroleum	Natural Gas	Nuclear Power	Hydro-electric Power	Other	Total
1973	848	314	341	83	272	2	1,861
1974	828	301	320	114	301	3	1,867
1975	853	289	300	173	300	3	1,918
1976	944	320	295	191	284	4	2,038
1977	985	358	306	251	220	4	2,124
1978	976	365	305	276	280	3	2,206
1979	1,075	304	329	255	280	4	2,247
1980	1,162	246	346	251	276	6	2,286
1981	1,203	206	346	273	261	6	2,295
1982	1,192	147	305	283	309	5	2,241
1983	1,259	144	274	294	332	6	2,310
1984	1,342	120	297	328	321	9	2,416

Note: Other energy sources include geothermal, wood, wind, waste, and solar. "Total" may not equal the sum of components because of independent rounding.

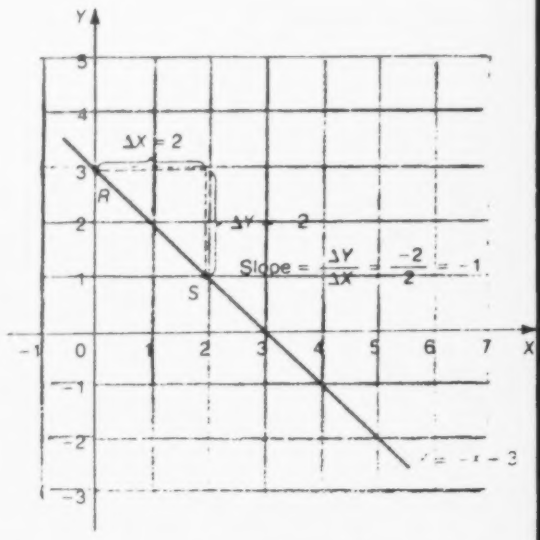
Source: Energy Information Administration, *Electric Power Monthly*, January 1985, and *Monthly Energy Review*, January 1985.

LESSON 3: LINEAR EQUATIONS

A. The graphing of linear equations that is most familiar to most math students is the slope-intercept concept. This has an extremely important application throughout the study of economics but I do not recall a single problem in any math book addressing such a usage. From elementary algebra on, slope is known to math students as the rise over the run, the vertical change over the horizontal change. We find the changes in the variable by subtracting the old value from the new value for both x and y. The first picture shows a positive slope and the second shows a negative slope.



Finding the Slope of Y = 2X + 1



Finding the Slope of Y = −X + 3

B. We took a demand schedule for cantaloupes and transferred it to a Cartesian graph. The students could see that the demand curve had to have a negative slope. We then examined a supply schedule for the same cantaloupes over the same price range and drew another graph. Of course, the supply curve had a positive slope. Students who had never had economics knew at this point that a demand schedule table showed the relationship between the various possible prices of an item or service and the quantity purchased over a given period of time.

They could now see graphically and tabularly that the law of demand states, other things equal, that the amount of a product a consumer is willing and able to buy is inversely related to the price. The substitution effect was also discussed at this point. After studying the inverse variation of the demand curve, it was obvious to most students that the supply schedule and curve were going to make the Law of Supply one of direct variation.

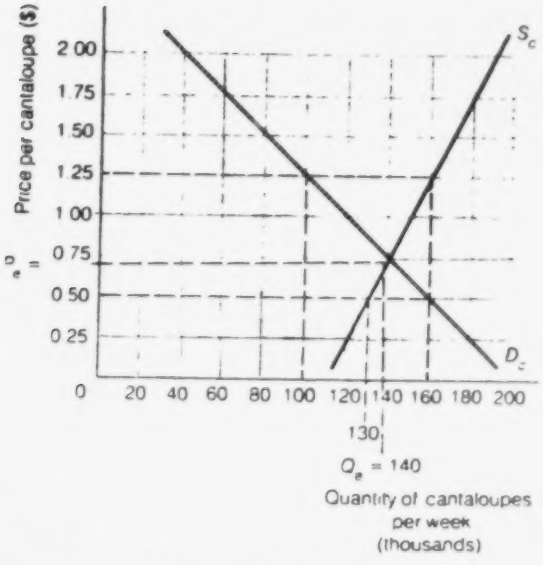
Demand Schedule for Cantaloupes

Price per Cantaloupe (P)	Quantity Demanded per Week (Q_d)
$2 00	40 000
1 75	60 000
1 50	80 000
1 25	100 000
1 00	120 000
0 75	140 000
0 50	160 000
0 25	180 000

Supply Schedule for Cantaloupes

Price per Cantaloupe	Quantity Supplied per week
$2 00	190 000
1 75	180 000
1 50	170 000
1 25	160 000
1 00	150 000
0 75	140 000
0 50	130 000
0 25	120 000

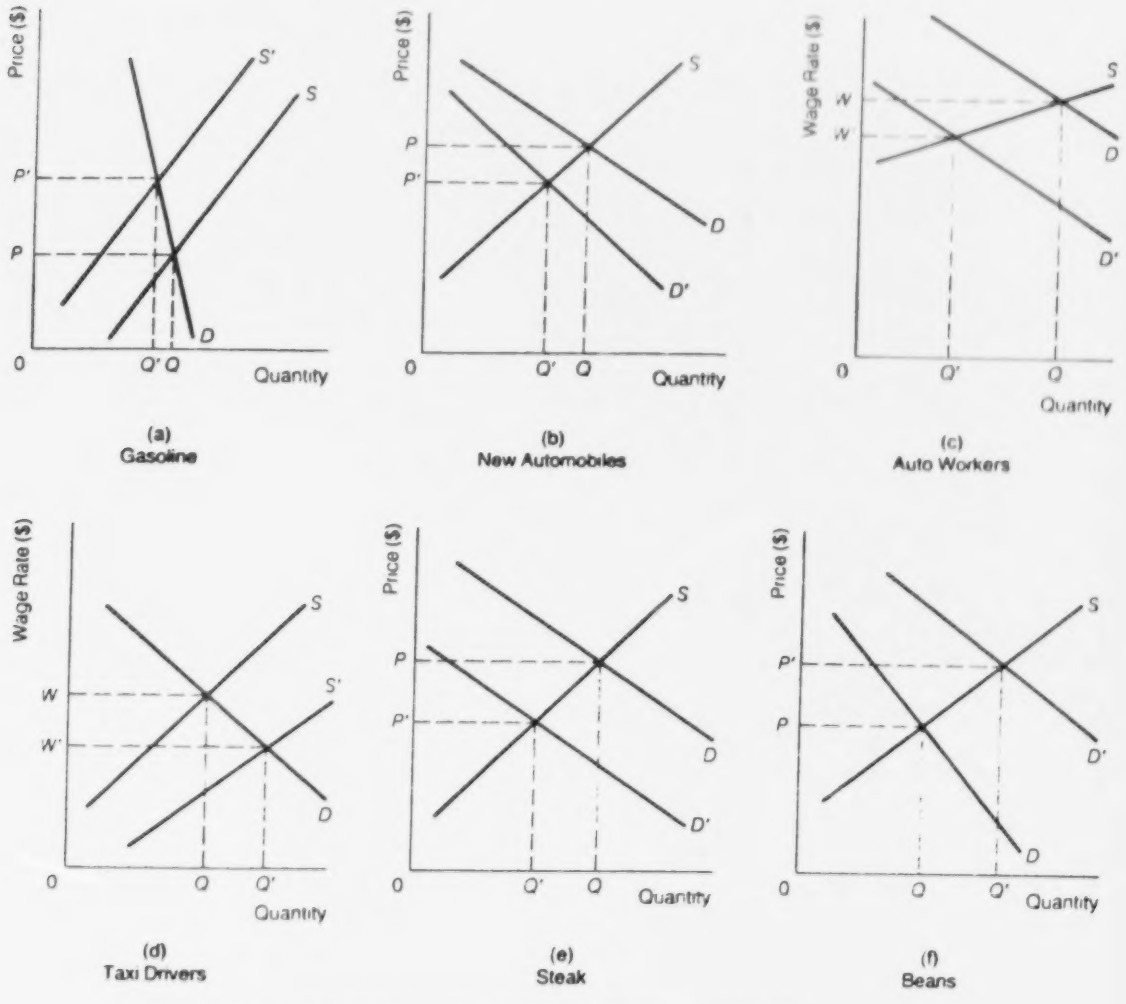
Because the demand curve and the supply curve have different slopes, they will intersect when drawn on the same grid. This point of intersection is the "market" or "equilibrium" price. If either or both of the curves change, a new equilibrium position will be established. If the curves hold their position but prices are changed, we will have a disequilibrium and surpluses or shortages will occur.



Equilibrium in the Market for Cantaloupes

Students are frequently asked in algebra to find the point of equilibrium but it is called the common solution of simultaneous equations. We established some equations based on department store items and solved them algebraically by addition or subtraction, resolved some of them by using matrices and determinants, and then graphed them to see that the common solution and the point

of equilibrium were one and the same. Many things simultaneously change economic patterns. We looked at a graph depicting how a change in one item cast changes across many areas.

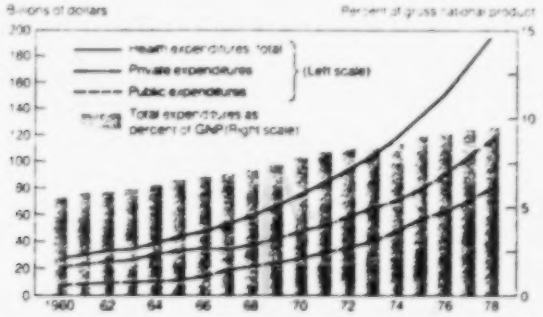


General Equilibrium Implications of a Decrease in the Supply of Gasoline

If the supply of gasoline decreased to S', the demand for new autos decreases, the demand for auto workers decreases, the demand for taxi drivers increases, the demand for steak decreases, and the demand for beans increases. All of these resultant changes have price and quantity effects.

It is important that students recognize early that all line graphs are not linear according to the traditional mathematical terminology. To emphasize this we studied the National Health Expenditures: 1960 to 1978. We compared this graph to the summation of two separate functions, f(a) and f(b) from earlier math work. I'm certain some of the students were never sure before this time as to why they summarized any functions.

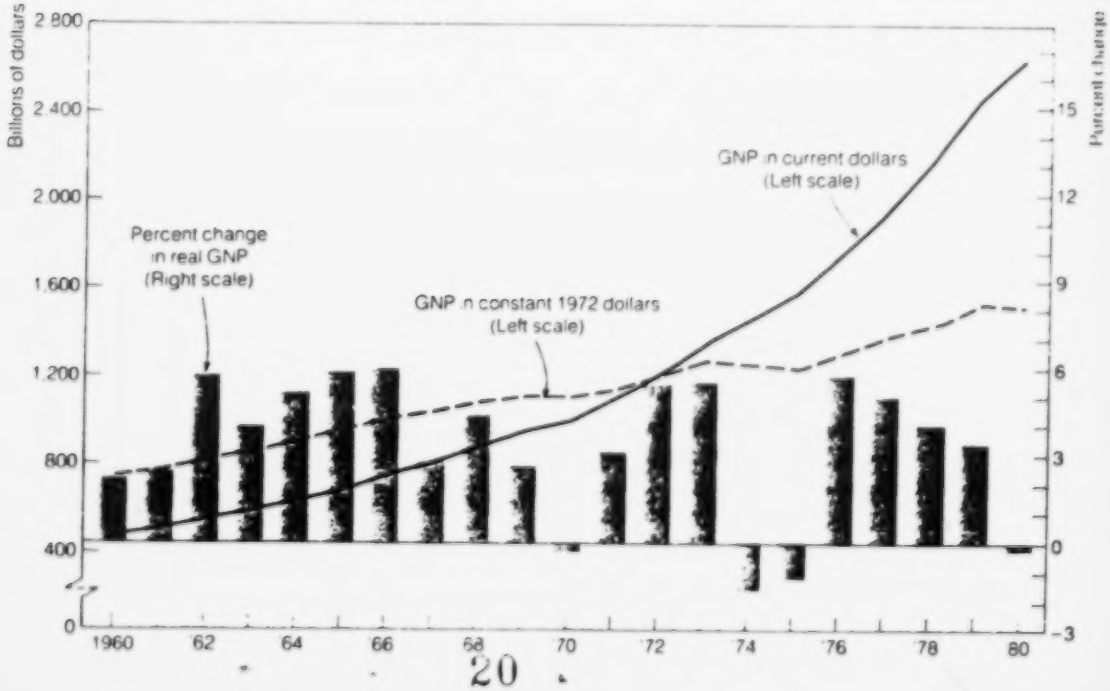
National Health Expenditures: 1960 to 1978



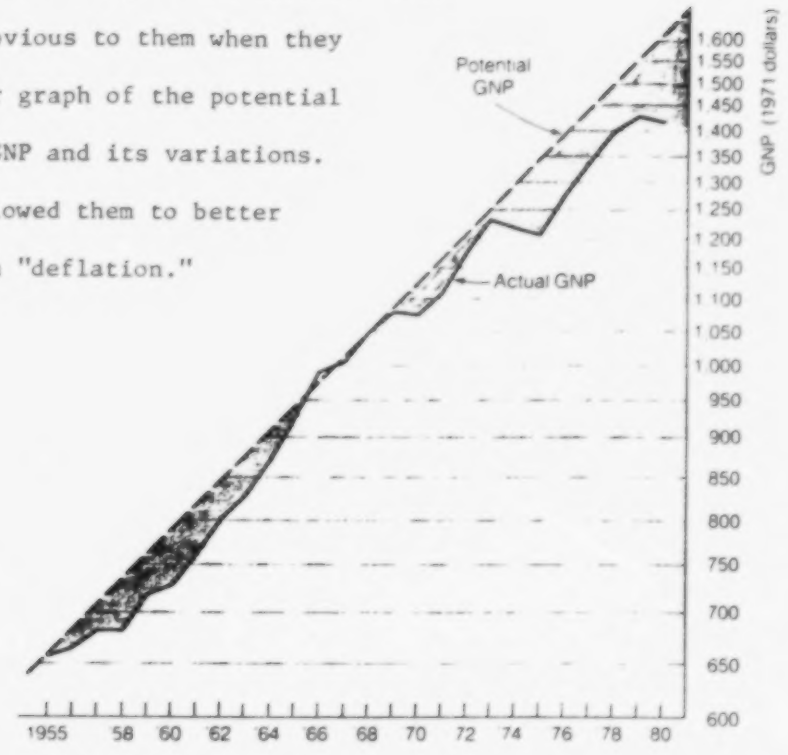
Sources: Chart prepared by U.S. Bureau of the Census. Data from U.S. Health Care Financing Administration

Sample of a line graph non-linear in nature.

This graph also brought into play the Gross National Product. At this point, I defined the GNP and introduced two more graphs for study and interpretation.



We looked at many of the graphs we were studying and noted the predictability of the curves. This was particularly obvious to them when they compared the linear graph of the potential GNP to the actual GNP and its variations. This graph also allowed them to better understand the term "deflation."

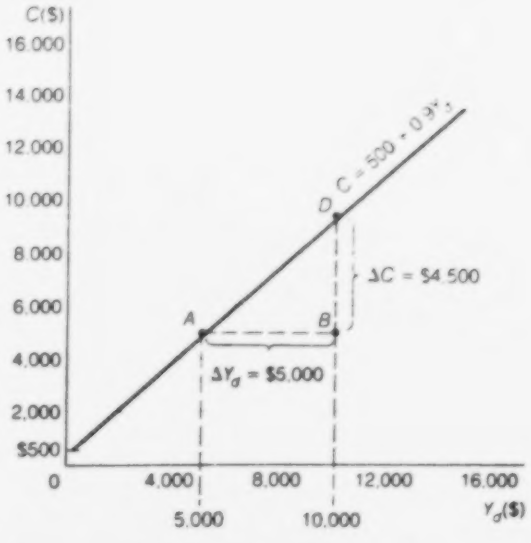


Actual and Potential Gross National Product

Potential GNP or the quantity of goods and services which the economy could produce if all members of the labor force were employed is given by the dashed line. Actual GNP is the quantity of goods and services (measured in 1972 dollars) which the U.S. economy actually produced during each respective year. When equilibrium GNP is less than potential GNP a deflationary gap is said to exist.

Source: Business Conditions Digest

We also examined the Consumption Function as a classic example of slope-intercept problems. The marginal propensity to consume is the change in consumption spending divided by the change in disposable income.



The Consumption Function C

If we look at the Consumption Function graph, we can see that the function is linear and the slope will be 4500/5000 or .9. The equation can then be written in standard slope-intercept form: $y = mx + b$ or $C = 500 + .9\ Y_d$ and where Y_d is disposable income. Students were then asked to derive an equation for the Saving Function, realizing that saving was the disposable income minus consumption spending, and to graph the results.

C. Assignment: Using the given table, draw supply and demand curves on the same grid plotting price vs. quantity. Find the equilibrium price. What will increased demand at all levels do to the equilibrium price?

SUPPLY-AND-DEMAND SCHEDULE FOR OIL

POSSIBLE PRICES (PER LITER)	QUANTITY DEMANDED PER DAY (MILLION LITERS)	QUANTITY SUPPLIED PER DAY (MILLION LITERS)
$1.00	227	416
.90	261	371
.81	284	333
.71	303	303
.62	333	273

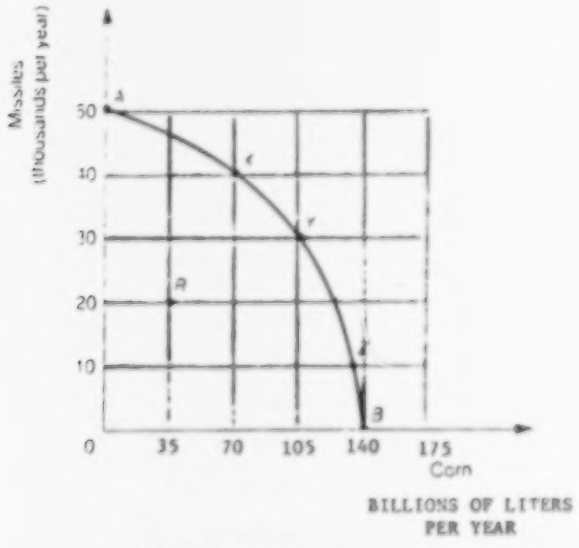
LESSON 4: OTHER CURVES

A. This is a good time to review basic parabolic patterns. If K represents any positive constant, then

1. if $y^2 = Kx$, the parabola opens toward the right
2. if $y^2 = Kx$, the parabola opens toward the left
3. if $x^2 = Ky$, the parabola opens upward
4. if $x^2 = Ky$, the parabola opens downward

Sometimes we study "half-parabolas" such as $y = -\sqrt{x}$. Try $y^2 = 12x$, $x^2 = 9 - 6y$, and $y = -\sqrt{x}$.

B. These curves are similiar to the Production Possibilities Curve. This used to be the traditional "guns and butter" curve but people found a substitute for butter and weapons as small as guns are seldom mentioned in the federal budget! Students should go from graph to tabular and tabular to graph. We also looked at the Total Cost Curve which is, as they know it from trigonometry, a standard "s" wave.

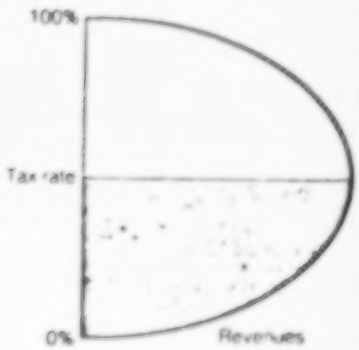


A Production Possibilities Curve

In this figure we have drawn a hypothetical production possibilities curve for an economy. Points *A*, *X*, *Y*, *Z*, and *B*, respectively, indicate various combinations of missiles and corn which the economy could produce if its resources were fully employed. At points inside the curve, such as *R*, resources are not fully and efficiently employed.

Since taxes are a much discussed item in the math classroom, particularly in the spring, lesson 4 might include an introduction to Laffer's Curve. It is a totally different type of graph than they are used to reading. Mr. Laffer's theory is, essentially, that for every dollar of tax revenus collected by the government, except as a single optimal point, two distinct tax rates exist, one high and one low.

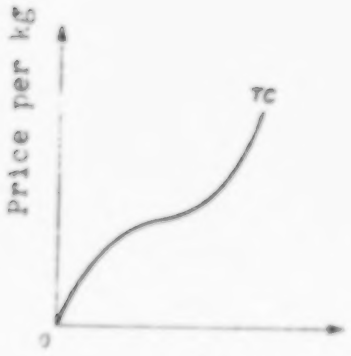
Mr Laffer's basic concept can be glimpsed in the accompanying sketch a so-called Laffer curve



Obviously, when the tax rate is zero, no revenue is collected. 100% tax rate would also yield no revenue because if all your income was confiscated, you wouldn't want to work. The optimal point where the most revenue is produced is at the extreme right edge of the curve where the shaded and unshaded regions meet. Despite the graph's appearance, that optimal point isn't necessarily at a 50% tax rate. It is probably on the upper half of the curve at a point where further tax increases would prove counterproductive. The closer you are to 100%, the more incentives and production decline and the tax revenues approach zero. A Harvard professor, Feldstein, said the Laffer curve is "something a congressman can digest in about 30 seconds and then talk about for months."

C. Assignment: Study the Total Cost Curve.

Identify the type of graph that generates the "s" curve, site an example and graph it.



Total Cost Curve

LESSON 5: ALGEBRA

A. Mathematics, particularly algebra, is a marvelous way to understand economic concepts. Augustin Cournot, the Frenchman who first stated the law of demand, wrote in 1838, "Anyone who understands algebraic notation, reads at a glance in an equation results reached arithmetically only with great labor and pain." Review solving simple equations with multiple variables for a specific variable.

B. Using their algebra, we discussed the demand curve as being a result of the demand function. The demand function relates the quantity of goods or services purchased to the other independent variables which affect that quantity. Price is generally the most important independent variable. Other variables will be related items such as income levels, credit terms, peer pressure, advertising, age and number of potential customers, and even the season or weather. We used cantaloupes again. An unspecified demand function using the price of a cantaloupe, the price of a honeydew as a substitute, and the purchasers' incomes could be expressed in quation form as $Q_d = F(P, P_h, I)$, where Q_d is the quantity of cantaloupes bought per week, P is the price, P_h is the price of the honeydew and I is the income of the customers. A specified demand function is one that has the appropriate constants expressed according to local data.

C. Assignment: Take a specified demand function such as $Q_d = 183\,000 - 80\,000P + 10\,000P_h + 0.101$ and substitute appropriate values for P (price per cantaloupe), P_h (price per honeydew), and I (average income of a family of four) and solve for Q. Experiment by changing one, two and three variables to see the economic implications in a changing demand curve.

I had the interesting experience of reading several economics books in preparing this unit. I was amazed at the variation in mathematical content contained in the various approaches. The book that proved to be the biggest help to me was Economics by Lila J. and Dale B. Truett, West Publishing Company, St. Paul, Minnesota, 1982. The material was current, easily understood, related beautifully to the math concepts I wanted reinforced, and prepared the students for an economics class the next fall. Graphs and tables in this paper were taken from that text with the exception of energy related materials. They were from Energy Facts 1984, U.S. Department of Energy, Washington, D.C. 20585, published May 1985.

EVALUATION

The evaluation was done mainly by observation and participation. Since the time was limited to start with, I did not want to give a day for testing and formal evaluation. I did ask the students on the first day of the unit to be prepared to bring in two different types of graphs or tabulations on the last two days. They were to be prepared to explain the source of the material, the type of graph, the mathematical generation of the graph, and its predictability and implications. Their enthusiasm was overwhelming. Most of them had more than two and they all wanted to have the opportunity to make a presentation. Their materials showed absolutely no overlap and ranged from strong individual concerns to some obviously good discussions with their parents. Topics covered: home computer prices and production, the TV boom in sales according to the market leaders' innovations, the rollercoaster ride of Apple stock and the subsequent development of Macintosh during a low Apple tide, bank failures from 1974 to 1984, the projected costs of higher and "higher" education, GNP, the unemployment pattern, the dimmed sparkle of diamond investing,

all that glitters (gold) is not good--down again in May, stocks stacking up against inflation, Minnesota sunflower acreage and sunflower production over ten years, the defense budget up 63% in 4 years, personal dollar investments, oil market jitters, the value of the travel dollar around the world over a three year period, the help wanted advertising index, the growth of the air force since 1907 according to strength by rank and number, how you read the Dow Jones, water related accidental deaths, goodwill donations over the last decade, union membership trends, and public school spending and the test scores.

Their enthusiasm was obvious and genuine and the questioning from the class to the presenters was good. Some entirely different students surfaced that week. They could see a lot of math in material that they had never viewed as mathematical. Some were quicker than others in deciphering the graphs but they all succeeded. Most of the slope problems they had previously encountered were related to engineering problems rather than the projection of an economics problem. They had never realized nor had I ever taught--probably because I didn't realize it either--that a demand curve is almost always linear, a total revenue curve is quadratic in nature, and a total cost curve is similar to a cubic. These are all patterns the students have worked with but without economic applications. What a tremendous bonus for us all! The whole class agreed that the units on graphing of functions at all levels, particularly the sections on slope, would be more meaningful to the students if some of the engineering problems could be replaced with some from the field of economics.

I have shared the enthusiasm of the students and myself with other department members and everyone is willing to incorporate the ideas in their curriculum plans next year. They think it's a good idea. I have also shared the packet with the economics teacher who was good enough to share his texts with me. He was ecstatic to see an inter-departmental interest.

Economists feel that economic events shape the world. Mathematicians think that math controls the world. Why not work together and control the shape?

A footnote: The students wanted to know, if they were my guinea pigs in designing this unit, would it not be right to have them name the course?

They came up with ECONOGRAPHS FOR GRAPHACONS*

*A graphacon (by student definition) is a junior who could not leave with the seniors and is conned into learning more than he/she expected.
*A graphacon (by teacher definition) is a student concerned with the mathematical application of economic principles.

1. Augustin Cournot, Researches Into The Mathematical Principles of The Theory of Wealth: 1838; New York: Augustus M. Kelley, 1960, p. 4.

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Energy graphs and tables reprinted by permission from ENERGY FACTS 1984, Department of Energy, Washington, D.C.

I had the opportunity to field test my revised economics unit with a group of juniors in an Essentials of Mathematics class this year. The class was composed of juniors and seniors who had all had a minimum of Algebra II and Trigonometry. The seniors in our school finished a week ahead of the juniors and, when polled, most of the juniors in that class indicated they would be taking economics in the fall. I gave them an overview of what I would like to address during their last week and their enthusiasm was great. I explained to them that

A. the math in economics is beautiful but sometimes because of time, the composition of the class, or the instructor's hierarchy of materials, did not get stressed.

B. if we concentrated on the reading and formation of graphs in the economic areas, that they would have a head start in understanding, and perhaps, in helping others to understand next year;

C. if they did not take economics in their senior year, it would still be an asset for them in understanding the current publications and news broadcasts;

D. they would be getting a practical application of math beyond that which the seniors had time for and also beyond their textbook presentations;

E. I would be using their evaluations to see if problems of this nature should be fit into the regular algebra, geometry, and pre-calculus classes to help give realism to the mathematical principles that so many students view as abstract.